Astrophysics Research And Analysis

High Precision Assembly of Thin Mirror X-ray Telescopes

Completed Technology Project (2016 - 2018)

Project Introduction

Lightweight high resolution x-ray telescope optics are one of the key technologies under development for next-generation x-ray telescopes. The ultimate goal of this effort is to realize optics with spatial resolution rivaling Chandra (<1 arc-sec) but with collecting areas that are larger by orders of magnitude. In the USA several institutions, including GSFC, MSFC, Harvard-SAO, MIT and Northwest University are working on a variety of approaches to this problem. An excellent example is the NuSTAR x-ray telescope, which teamed Cal Tech, GSFC, Columbia University and LLNL to produce a superb set of hard x-ray optics. The telescope was composed of thousands of 0.2 mm-thick glass mirrors which were epoxied into place around a spindle structure. While very light weight, this process resulted in ~1 arc min resolution. We want to achieve ~100 times better with similar mass. A group at NASA GSFC has recently demonstrated an alternative thin-glass assembly procedure that has achieved ~7 arc sec resolution with x-ray tests. Further progress towards 1 arc-sec will require mirrors with improved figure, lower stress coatings, improved alignment, better metrology, and low stress bonding. Many of the difficulties with current mirror assembly practice stem from the use of epoxy as a bonding agent. Epoxy has many disadvantages, including high shrinkage, large CTE and creep, resin aging effects, water absorption, outgassing, low tensile strength, exothermicity, and requiring large amounts of time and/or heat to cure. These effects can cause errors that become “frozen in” to the bond with no possibility of correction. We propose to investigate replacing epoxy with low temperature, low shrinkage solder alloys. We use these solders in conjunction with high power, millisec-long pulses from a fiber IR laser to deliver controlled amounts of heat into the bond area. We have demonstrated that laser pulses can be used to actuate carefully designed bonds by permanently compressing or expanding a very thin and brief surface melt in the solder by amounts controlled in the nanoscale range, allowing post assembly correction of the mirror mount points. We believe this technology will be one of the keys to realize a sub-1 arc-sec thin-glass x-ray telescope.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

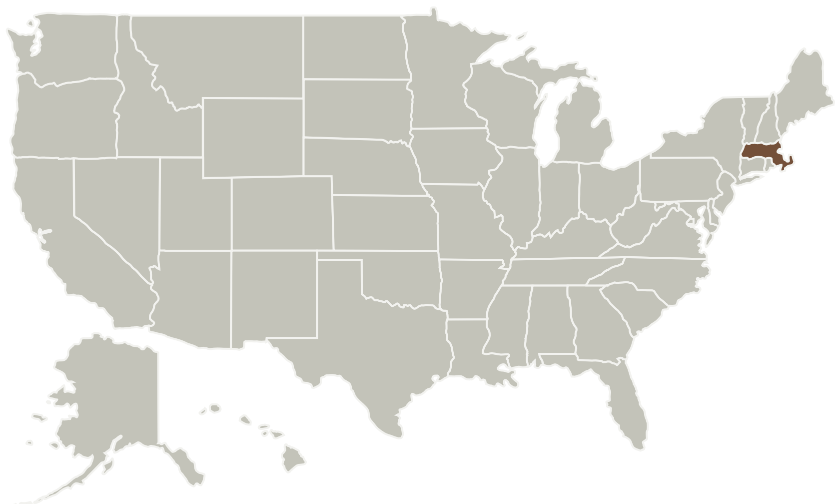
Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Astrophysics Research and Analysis

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations
Massachusetts

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

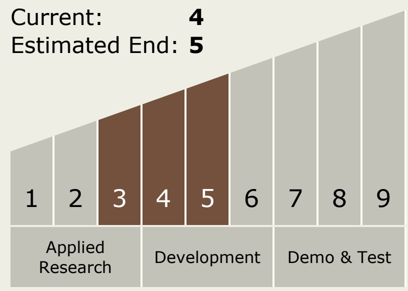
Mark Schattenburg

Co-Investigators:

Ralf Helimann
Michael P Corcoran
Martin Klingensmith

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.2 Observatories
    └ TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System